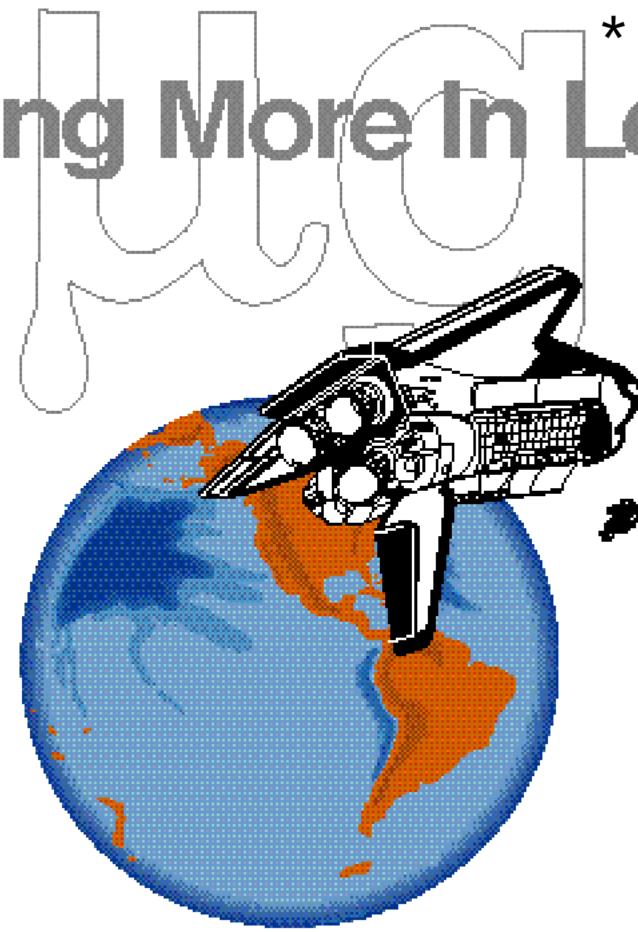
National Aeronautics and
Space Administration
Langley Research Center
Office of Education

Educator's Guide	
Teachers & Students	Grades K-8

CONNECT
VIDEO SERIES

Doing More In Less*



Program 4 of 4

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*The graphic µg represents microgravity. The µ is the Greek symbol for the lower case letter m (for micro), and g is a scientific abbreviation for gravity.

Doing More In Less is a partnership between the NASALangley Office of Education and the following organizations:

National Aeronautics and Space Administration: Langley Research Center, Learning Technologies Project Office; Lewis Research Center; Marshall Space Flight Center; NASA Classroom of the Future (Wheeling, WV)
Program Partners: Busch Gardens Williamsburg, Williamsburg/James City County Public Schools, York County Public Schools;
Education Departments: Alabama Department of Education; Kentucky Department of Education, North Carolina Department of Public Instruction, South Carolina Department of Education, Virginia Department of Education, West Virginia Department of Education;
Broadcasters: AL ETV (Alabama), KET (Kentucky), SC ETV (South Carolina), StarNet, WBRA(Roanoke, VA), WCVE (Richmond,VA), WHRO (Norfolk, VA), WNVT(Northern VA), WVPT(Harrisonburg, VA), WCET(Cincinnati, OH), WVIZ (Cleveland, OH)

Series Overview & Program Format (Pgs. 1–6)

- Introduction to CONNECT Series
- Introduction to CONNECT 4: *Doing More In Less*
- NASA's Contribution to Microgravity Science Research

Program Guide Contents

Program Partners

- NASA Langley Research Center, Learning Technologies Project Office
- NASA Lewis Research Center
- NASA Marshall Space Flight Center
- Busch Gardens Williamsburg
- WHRO-Public TV
- Williamsburg-James City County Schools
- York County Schools

Need More Copies?

Section 1

This section contains valuable information concerning the CONNECT Series and *Doing More In Less*, Program 4 of the CONNECT Series. This information will allow educators to become familiar with the purpose of the CONNECT Series and the *Doing More In Less* program. Also, educators will be presented with highlights about the Human Exploration and Development of Space mission of the National Aeronautics and Space Administration (NASA).

The *Doing More In Less* program is a collaboration between three NASA Centers: NASA Langley Research Center's Office of Education and the Learning Technologies Project Office, NASA Marshall Space Flight Center's Microgravity Research Division, and NASA Lewis Research Center's Microgravity Science Division. Additional program partners include WHRO Public TV, Busch Gardens Williamsburg, the Williamsburg-James City County School Division, and the York County School Division. These partners share in their commitment to education and children and proudly present this CONNECT program to the educational community.

We encourage the widest possible distribution and use of our educational programs and materials. Specifically, there is no claim of copyright by the U.S. government concerning the CONNECT Series. Therefore, our permission is not required to either tape each broadcast or to copy the associated print materials for classroom use and/or retention in your school's library.

INTRODUCTION TO THE CONNECT VIDEO SERIES

The CONNECT Video Series consists of four, 30-minute programs delivered to both K-4 and 5-8 audiences. Each program in the series will feature one of the four NASA Strategic Enterprises. It is this “content” that drives the uniqueness of the CONNECT programs. The Enterprises include Aeronautics and Space Transportation Technology, Human Exploration and Development of Space, Earth Science, and Space Science.

SERIES OBJECTIVES

- Demonstrate the connection between the concepts and skills taught in the classroom and their application in the workplace.
- Address specific national mathematics standards and support state curriculum frameworks and standards.
- Actively engage students in problem solving, mathematical reasoning, and communicating mathematics.
- Build activities within the program’s design that encourage students to apply mathematical operations involving number sense and numeration, measurement, statistics and probability, and patterns and relationships.

ABOUT THE PROGRAM FORMAT

- NASA Guest: features a NASAengineer, scientist, or technician to illustrate the application of classroom lessons to the workplace
- Activities: involves the use of hands-on activities drawn from NASA educational products, including the NCTM math activity books, *Mission Mathematics*, developed in collaboration with NASA
- Students: highlights elementary and middle school students and classrooms that have conducted the program’s experiment and shared the results with viewers
- Challenge Point: includes pause period, whereby students are presented with data and, working in pairs or small groups, are encouraged to perform analysis and data interpretation
- Call, Write, E-mail: includes opportunity for students to call, write, or e-mail before the program and following the Challenge Point portion of the program with questions related to the program topic, the activity, or the guest
- Print Materials: provides registered educators with background on the program content, the guest, and the featured activity. Materials include a master copy of Challenge Point worksheets for copying and distribution to students and a listing of additional resources related to the program topic
- Web Site: enables viewers to register for the program, to download print materials, to submit evaluation, and to acquire additional information

NASA Strategic Plan identifies “Educational Excellence” as one of its strategic outcomes and states:

“We involve the education community in our endeavors to inspire America’s students, create learning opportunities, and enlighten inquisitive minds.”

NASA – Investing in America’s future through excellence in education

NASA is committed to promoting excellence in education, to supporting the teaching profession, and to increasing the awareness of the impact science, mathematics, and technology will have on the quality of life in the 21st century.

Call-In
(for broadcast date only):
864-3991 (local) or
1-888-835-0026 (toll free)

E-Mail:
connect@edu.larc.nasa.gov

Web Site:
http://edu.larc.nasa.gov/connect/

INTRODUCTION TO HUMAN EXPLORATION AND DEVELOPMENT OF SPACE ENTERPRISE

Reflect on what has been achieved in human flight in this century. Who would have imagined these accomplishments possible? Let's look forward. Imagine traveling to space stations, to the Moon, to Mars and other destinations. Imagine colonies of space explorers working in laboratories on the Moon and Mars or constructing large telescopes that provide detailed images of planets around other stars.

Imagine commerce flourishing in space, with solar power satellites or a lunar solar energy plant to power lunar operations. Imagine school children learning their lessons in astronomy, geology, or biology by teleoperated classroom instruction from the Moon. Ponder the adventure of field trips to new planetary destinations. Imagine the first human mission to Mars, composed of an international crew, going in peace to conduct joint research and to plant the seeds of a new world.

These images are part of the vision of sustained human presence in Space of the Human Exploration and Development of Space Enterprise (HEDS). This Enterprise is one of four Strategic Enterprises reflecting the core, externally oriented missions of the Agency. HEDS is a catalyst for development of the space frontier for commerce and science. The goals for the HEDS Enterprise include the following:

- Increase human knowledge of nature's processes using the Space environment
- Explore and settle the Solar System
- Achieve routine Space travel
- Enrich life on Earth through people living and working in Space

Among the research areas that are found under the HEDS Enterprise is the Office of Life and Microgravity Sciences and Applications (OLMSA). This office leads the nation's efforts in life and microgravity sciences, related technology development, and applications using the attributes of the space environment to advance knowledge, to improve the quality of life on Earth, and to strengthen the foundations for continuing the exploration and use of space.

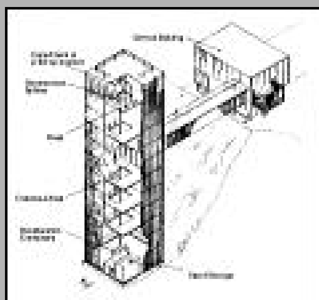
In this CONNECT program, *Doing More In Less*, students will explore the concept of microgravity. Students will observe featured student "researchers" from the the Williamsburg-James City Schools and the York County Schools conducting an experiment to investigate the effects of varying the amount of fuel (fizzing antacid tablets) to the difference in time from fuel ignition to landing. The same activity will be used with the K-4 and the 5-8 programs but with varying complexity to accommodate the mathematical experiences of the student groups. By working in pairs or small groups during the Challenge Point portion of the program, viewers will better understand how research teams must work together to conduct investigations.

Additional information on NASA's Human Exploration and Development of Space (HEDS) program and microgravity research can be found on the HEDS homepage at http://www.osf.hq.nasa.gov/heds

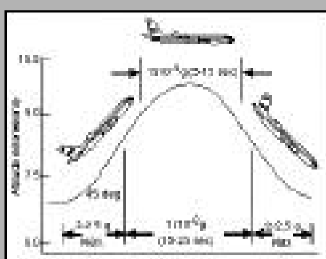
Creating Microgravity

Microgravity can be achieved with a number of technologies, each depending upon the act of free fall.

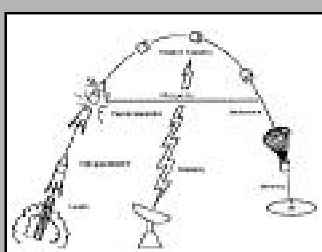
Drop Tower



KC-135 Airplane



Sounding Rockets



International Space Station

Check the following URL for a description and diagram of these technologies. http://quest.arc.nasa.gov/smore/background/microgravityy/MGintro3.html

LEARN ABOUT NASA'S CONTRIBUTION TO MICROGRAVITY SCIENCES RESEARCH

We often separate ourselves from day-to-day distractions to work more efficiently. Isolation from these events often improves the quality of our work and learning. Scientists, too, often wish to escape the ever-present constraints of Earth's gravity and atmosphere to obtain fresh perspectives on everyday events such as materials processing, heating, and fire safety. Free from the confines of gravity, they can impose precise conditions on experiments to learn more about these phenomena and how they can be controlled. For example, the way a fire starts and spreads can be studied without the interference of gravity, giving scientists a better understanding of the processes involved and, perhaps, leading to improved fire safety. Mixtures that separate on Earth because of different densities among their components can be mixed evenly and processed in microgravity. This process allows scientists to study the processing of such materials and to create advanced materials for study and comparison.

Without the pushing, pulling, and other effects of gravity, more perfect inorganic crystals can be produced, which may eventually lead to the creation of advanced computer chips and semiconductors. The growth of near-perfect protein crystals will enhance our understanding of protein molecular structures and may speed the development of improved drugs. Also, scientists can use the microgravity environment to learn how the presence or absence of gravity affects living organisms. This knowledge will aid long-term space efforts and also will provide a better understanding of life on Earth by allowing scientists to study biological processes and phenomena impossible to study in gravity.

For very short periods of time, microgravity can be created on Earth. Experiments can be placed in containers and dropped down tubes or chutes in **drop towers** to a cushioned landing. These very short periods of microgravity, measured in fractions of seconds to a few seconds, often are sufficient to test theories or equipment designs.

By flying **aircraft** in a careful series of roller-coaster-like arcs, brief periods of microgravity– alternating with periods of increased gravity– can be produced. These somewhat longer periods of microgravity, usually 15 to 60 seconds, are suitable for conducting some experiments, for verifying that experiments and hardware will work in microgravity, and for helping train astronauts to work in the absence of gravity.

Sounding rockets provide longer periods of microgravity – approximately 4 to 6 minutes. These payloads arch as high as 250 km above Earth's surface before parachuting to be recovered.

Additional information on NASA's Human Exploration and Development of Space (HEDS) program and microgravity research can be found on the HEDS homepage at http://www.osf.hq.nasa.gov/heds

At the **elementary and secondary levels**, NASA seeks to enhance the knowledge, skills, and experience of teachers and to capture student interest in science, mathematics, and technology through the demonstration of integrated applications of related subject matter.

NASA's science, mathematics, and technology education programs and activities leverage its inspiring mission, unique facilities, and specialized workforce.

MEET THE STUDENT HOST

VAN M. HUGHES

Van M. Hughes is a 14 year old freshman at Oscar Smith High School in Chesapeake, Virginia, where he maintains an Aaverage. He also attends the Governor's School for the Arts and is a very promising actor. In addition to the CONNECT Series, Van starred in the 1996 NASA instructional video, *Think BIGG*. On weekends Van plays guitar and is the lead singer in his own young country teenage band , "The Noodles."

MEET THE PROGRAM HOST

M. D. "SHELLEY" CANRIGHT, Ph.D.

Dr. M.D. "Shelley" Canright serves as Precollege Officer in the Office of Education at NASALangley Research Center, Hampton, Virginia. She is responsible for planning and implementing the Center's precollege educational programs and for developing new products that integrate NASA's four enterprises with national education goals and standards. Dr. Canright has 18 years of professional work experience in the field of education, spanning local (classroom and school board) to federal-level positions and experiences. Shelley has developed and managed a number of educational programs and projects that have received national recognition and awards, including a U.S. Presidential Letter of Commendation. Her doctorate in Instructional Systems, with a research interest in instructional television, makes her contributions to the ongoing development of the CONNECT Series invaluable.

MEET THE PROGRAM PARTNERS

Doing More In Less is a partnership between the NASALangley Office of Education and the following organizations:

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Program Partners: Busch Gardens Williamsburg, Williamsburg/James City County Public Schools, York County Public Schools

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Broadcasters: AL ETV (Alabama), KET (Kentucky), SC ETV (South Carolina), StarNet, WBRA(Roanoke, VA), WCVE (Richmond,VA), WHRO (Norfolk, VA), WNVT (Northern VA), WVPT (Harrisonburg, VA), WCET (Cincinnati, OH), WVIZ (Cleveland, OH)

MEET THE NASA GUEST RESEARCHERS

FELECIA EWING

MARSHALL SPACE FLIGHT CENTER

Felecia Ewing was born in Huntsville, Alabama, graduated from SR Butler High School in 1984, attended the University of Alabama in Huntsville, and received a degree in Biology. Ms. Ewing comes from a family background of teaching and community service. Her mother taught for 25 years, and her father was a pastor for 39 years. Ms. Ewing has served her community and those abroad in various areas such as tutoring and mentoring programs. Her past 14 years have provided her volunteering opportunities with churches, schools, children's homes, and community centers to help build leadership and other skills among young people.

Ms. Ewing serves as a Research Associate with the Universities Space Research Association in the Space Sciences Laboratory at NASA's Marshall Space Flight Center, Huntsville, Alabama. Her primary duties include developing purification and crystallization protocols for various proteins in which to conduct ground-based research. In addition, she is responsible for the testing, research, and development of flight hardware. She is a published author in the Journal of Crystal Growth and Acta Crystallographica. Ms. Ewing enjoys the research and the work environment and keeps her horizons open. Her near-term goals include completing a professional degree in education and becoming a teacher.

NANCY RABEL HALL

LEWIS RESEARCH CENTER

Nancy Rabel Hall is a research scientist in the Microgravity Science Division of the NASA Lewis Research Center. She is the Deputy Project Scientist for the Surface Tension Driven Convection Experiment-2 (STDCE-2), which flew as part of United States Microgravity Lab-2 mission onboard shuttle flight STS-73 in Sept. 1996. She is also the Project Scientist for the Extensional Rheology Experiment that is scheduled to fly on a sounding rocket in early 1999 and Project Scientist for the Preshear History and Uniaxial Elongation in a Microfilament Extensional Rheometer experiment that will be performed in the glove box facility of the Space Shuttle in 2000. As a project scientist, she represents the principal investigator and serves as a liaison between the principal investigator and the engineering team to ensure the scientific integrity of each experiment.

Mrs. Hall has always been interested in science, and in the 7th grade her interest settled on physics and astronomy. She received a BS degree in Space Sciences from the Florida Institute of Technology in 1989. Today she is working on her master's degree in Mechanical Engineering, enjoys science fiction, and is an amateur radio operator.

Section 2

Program Preparation Activities (Pgs. 7–11)

- Complete simple experiment found in Appendix A
- Check reading and science comprehension with activity found in Appendix B
- Get families involved through Home Connection, Section 5
- Read aloud information on the NASA Guests

Preparing for the Challenge Point

- Make copies of appropriate worksheet (Pgs. 9–11)
- Divide students into small groups or pairs.

The information contained in this section is designed to prepare teachers and students to watch the (video) program. There are 5 preprogram, or preparation, activities: (1) read aloud to the students the brief summary of "Meet The NASA Guest Researchers," on page 6; (2) one week or a few days before the broadcast, conduct with students the simple sink and float experiment listed in Appendix A; (3) have students dissect and illustrate the article on microgravity (K-8) and gravity (5-8) listed in Appendix B; (4) divide students into small groups or pairs in preparation for the Challenge Point period; and (5) involve your students' families in the experience by sending home the **Home Connection** activity listed under Section 5 of this guide.

Program Preparation

Class Experiment

Refer to pages A1–A8 for a Sink and Float activity that has proved to be a great way to introduce students to the concepts of gravity, density, and microgravity and to get them thinking about the effects reduced gravity might have on the way liquids, solids, and materials behave. The activity has been developed and modified to be appropriate for K-4 and 5-8 students. This activity has been developed and classroom tested by Melissa Rogers, National Center for Microgravity Research on Fluids and Combustion, NASA Lewis Research Center.

Visualizing Microgravity and Gravity

<u>K-8: Microgravity</u>. Help students collect a working understanding of the concept microgravity. Refer to page B2 for a short article explaining the concept of microgravity, "What is Microgravity?" Copy and distribute the article to students. Next give students one 5-1/2 x 7 inch blank index card for each paragraph in the article. Working with the students, read aloud each paragraph and discuss. Have students draw an illustration of the "meaning" of the paragraph as they understand it. Then have the students cut apart the article and paste each article paragraph and accompanying illustration on a new sheet of paper creating a "storybook" on microgravity. Finally, have students gather in small groups and share their books. What similarities and differences do they find in the illustrations in their interpretations and understanding?

<u>5-8: Gravity</u>. Follow the same procedures as above for the article, "The Story of Gravity" on page B3.

Preparing for the Challenge Point Period

Before watching the video, prepare for the program's Challenge Point period:

1. Make copies of the appropriate Challenge Point Worksheet and distribute one copy per student.
2. Divide students into small groups or pairs. Depending on the students, teachers may wish to do the Challenge Point as a large group.
3. Provide a calculator per group (optional) for grades 5–8.

Program Materials

- Challenge Point Worksheet
- Pencils
- Calculators (optional)

Program Vocabulary

- acceleration - *the rate at which an object's velocity changes with time*
- gravity - *the attraction of all objects to one another due to their mass*
- mass - *a measurement of a body's weight that takes into account its resistance to movement*
- microgravity - *the condition of free fall within a gravitational field in which the weight of an object is significantly reduced compared to its weight at rest on Earth*
- weight - *the measure of the object's resistance to gravity*

BEFORE THE PROGRAM

The following suggestions will prepare the students for the program and help focus their attention on specific elements within the program's content.

VOCABULARY

1. Introduce the 5 vocabulary terms: acceleration, gravity, mass, microgravity, and weight.
2. Challenge students to consider the relationship between mass and weight and between gravity and microgravity.

PREREQUISITE MEASUREMENT AND STATISTICAL CONCEPTS

Gr. 5-8 students should be able to

- Use rounding to relate decimal values to whole numbers
- Find the mean and median for a set of data

DISCUSSION QUESTIONS

List the following questions on the board. Have students discuss each question. Questions very similar to these will be asked of the featured guest. Following the program, go back to the questions and rediscuss.

1. What type of microgravity research are you doing? What applications might this research have here on Earth?
2. If liquid in microgravity forms into a sphere, how are the astronauts able to measure the amount of fuel they have left in the Space Shuttle's fuel tank while in space?
3. Does the term "zero gravity" mean the same thing as "microgravity"? Is it correct to say that the astronauts are in zero gravity when in space?

Consider listing the questions that other students ask during the program's call-in period. Have students re-examine those questions after the show as a review of what was presented. This review would be a great check for student understanding and a good lead-in to conducting the lesson activity, "Fizzy-Tablet Rocket" (See pages C1–C8).

CALL-IN/ E-MAIL OPPORTUNITY

Divide the class into small groups and have each group come up with a list of questions they have about the program topic. Have groups share their group questions.

1. List each group's questions on the board and then select 2 to 3 questions from the list as a class.
2. E-mail these questions to CONNECT at connect@edu.larc.nasa.gov

   OR

3. Call in with a question during the CONNECT call-in period:
   Toll Free 1 (888) 835-0026 Local 864-3991

CHALLENGE POINT WORKSHEET
PRIMARY LEVEL (GRADES K-4)

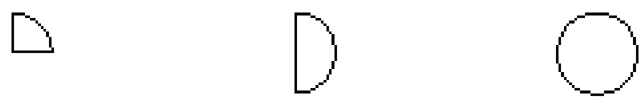
(See answer key, p.14)

Flight Time in Seconds
from ignition to landing

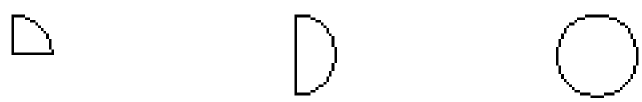
size / trial	* (1/4)	** (1/2)	(1)
1	21	12	6
2	22	13	7
3	30	14	6

* two 1/4 pieces ** one 1/2 piece

1. Which tablet size took the longest from ignition to landing? (Circle your answer.)



2. Which tablet size was the fastest from ignition to landing? (Circle your answer.)



3. Compare the flight time for two 1/4 pieces and the flight time for one 1/2 piece. What reasoning do you have to explain the results?

____

____

____

4. Predict what would happen to the flight time if two 1/2 table pieces were put in a canister. How would this flight time compare to the time for the one whole tablet?

____

____

____

CHALLENGE POINT WORKSHEET
INTERMEDIATE LEVEL (GRADES 5-8)

(See answer key, p.15)

Flight Time in Seconds
from ignition to landing

trial \ size	(1/4)	(1/2)	(1)
1	29.50	17.22	10.06
2	28.23	16.88	11.31
3	24.36	18.10	12.25

1. Round the flight times of each entry. *(Hint: Round up to the greater whole number if decimal number is 0.5 or greater.)*

Flight Time in Seconds
from ignition to landing

trial \ size	(1/4)	(1/2)	(1)
1	30	17	
2	28		
3			

2. Find the mean and the median flight time for each tablet strength.

	MEAN	MEDIAN
1/4 tablet		
1/2 tablet		
1 whole tablet		

3. List the different ways the results of the experiment might be compared.

___

___

___

CHALLENGE POINT WORKSHEET
INTERMEDIATE LEVEL (GRADES 5-8)
CONTINUED

(See answer key, p.16)

4. Draw a diagram to illustrate your answer to the given situation:

Suppose that we want to do 10 rocket launches using whole tablets, 10 launches using 1/2 tablets, and 10 launches using 1/4 tablets. How many tablets do we need for our investigation?

Section 3

Program Viewing and Exploration
(Pgs. 12–25)

Viewing the Program

The *Doing More In Less* CONNECT program introduces students to the field of microgravity with a dialog between the program host and the NASA guest researchers. The program highlights students conducting an experiment that explores the effects of varying the amount of (antacid tablet) fuel to see whether there is a difference in time from fuel ignition to landing. Data generated from the students' experiment will be displayed to the viewers and viewers, will be challenged to interpret and analyze the data during the program's Challenge Point Period.

Interactive Challenge Point

Challenge Point Period

This interactive program requires that each student record data on worksheets that are used during the program. Student worksheets and teacher answer keys are provided in this packet. Please note that there are worksheets and answer keys for K-4 and 5-8. Each CONNECT program is broadcast to two different audiences at two different times with modifications made to the experiment and presentation, as appropriate for the two audiences.

Grades K–4 Challenge Point

The **K-4 show** and its associated Challenge Point will emphasize experimentation with one variable, fuel amount. Students will examine the relationship of the tablet size (fuel) to the "rocket's" flight time. The constant in the experiment will be the amount of water added to the film-canister rockets. The changing (independent) variable will be the amounts of fuel tested: one whole tablet, 1/2 tablet, and 1/4 tablet. Students will work with trial data to examine the differences in flight times and to make comparisons and predictions. Number sense and numeration, measurement, patterns and relationships, and fractions will be emphasized.

Grades 5-8 Challenge Point

The **5-8 show** and the Challenge Point will emphasize the same variable as the K-4 fuel amount and its relationship to flight time. Students will round the flight time data to the nearest whole number and will then be asked to compute the mean and median for the data. Students will be given a related problem to diagram. Number sense and numeration, measurement, statistics and probability, patterns and relationships, and fractions and decimals will be emphasized.

Further Exploration

Further extensions to the program and additional Human Exploration of Space resources are outlined on pages 17–25.

Evaluation Form

http://edu.larc.nasa.gov/connect/evaluation.html

What did you think of *CONNECT 4: Doing More In Less?* Please complete the enclosed postage-paid evaluation card. Or, to send us your comments electronically, go to http://edu.larc.nasa.gov/connect/evaluation.html

NCTM Standards

- Number Sense and Numeration
- Measurement
- Statistics
- Patterns and Relationships
- Fractions and Decimals

Program Objectives

- Collect, organize, analyze, and interpret data
- Use standard unit of measure (seconds)
- Work cooperatively in pairs/teams

Challenge Point Tip

- Arrange students in pairs or small groups before the program begins
- Distribute copy of Challenge Point worksheet to each student
- Distribute one calculator per group (optional)

Challenge Point Assessment Tip

- Talking and writing about predictions and interpretation of data help students confirm their learning

Technology Tip

Providing calculators for students to use may facilitate reasoning for students who have not mastered multiplication or division.

THE PROGRAM CHALLENGE POINT

Built within the program's design is a pause period (approximately 4 minutes long) in which students will be asked to look at generated data and, working in pairs or small groups, respond to questions, one at a time, as listed on the Challenge Point Worksheet. (See p. 9 [K-4] and pgs. 10 and 11 [5-8].) This pause period is important for providing students the opportunity to work with information presented up to this point and to actively examine and work with data in support of the NCTM standards.

DURING THE CHALLENGE POINT PERIOD

Teacher as Facilitator

Built within the program's design is a pause period in which students will be asked to look at data and, working in pairs or small groups, respond to questions and complete tables or graphs detailed on the Challenge Point Worksheet.

1. Make copies of the Challenge Point Worksheet and distribute one copy per student before starting the program.
2. Depending on the students, teachers may wish to have a large group or divide students into pairs or smaller groups. This grouping should be done before the program.
3. The teacher is to act as a facilitator during this program time, supporting and guiding the students in discussion and in responding to the worksheet questions.

Student as Researcher

By working in pairs or small groups, students will better understand how NASA research teams must work together to analyze and interpret findings and to communicate results in written, oral, and graph forms.

1. Observe the data shown on the television, as recorded by the featured school and as displayed on the worksheet.
2. Questions pertaining to the data will be presented one at a time on the videotape. You will have a limited amount of time to discuss the question with your partner(s), calculate an answer, if necessary, and write down a response.
3. Feedback to the questions will be presented to you at the end of the Challenge Point period. Review your answers. Following the program, continue your discussions if necessary.

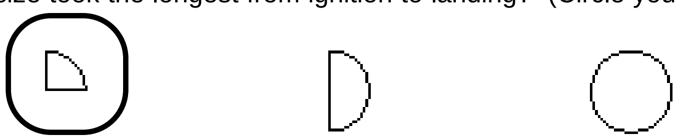
CHALLENGE POINT WORKSHEET
PRIMARY LEVEL (GRADES K-4)
ANSWER KEY

(for worksheet on page 9)

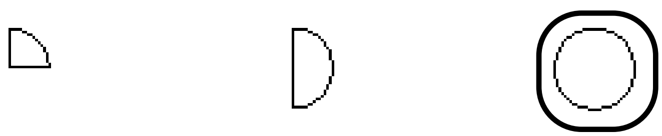
Flight Time in Seconds
from ignition to landing

trial \ size	(1/4)	(1/2)	(1)
1	21	12	6
2	22	13	7
3	30	14	6

1. Which tablet size took the longest from ignition to landing? (Circle your answer.)



2. Which tablet size was the fastest from ignition to landing? (Circle your answer.)



3. Compare the flight time for two 1/4 pieces and the flight time for one 1/2 piece. What reasoning do you have to explain the results?
   The smaller tablet took longer to build up enough gas to produce the pressure necessary to blast the lid off the canister

4. Predict what would happen to the flight time if two 1/2 tablet pieces were put in a canister. How would this flight time compare to the time for the one whole tablet?

CHALLENGE POINT WORKSHEET
INTERMEDIATE LEVEL (GRADES 5-8)
ANSWER KEY
(for worksheet on page 10)

Flight Time in Seconds
from ignition to landing

trial \ size	(1/4)	(1/2)	(1)
1	29.50	17.22	10.06
2	28.23	16.88	11.31
3	24.36	18.10	12.25

1. Round the flight times of each entry. *(Hint: Round up to the greater whole number if decimal number is 0.5 or greater.)*

Flight Time in Seconds
from ignition to landing

trial \ size	(1/4)	(1/2)	(1)
1	30	17	10
2	28	17	11
3	24	18	12

2. Find the mean and median flight time for each tablet strength.

	MEAN	MEDIAN
1/4 tablet	27.36	28.23
1/2 tablet	17.40	17.22
1 whole tablet	11.21	11.31

CHALLENGE POINT WORKSHEET
INTERMEDIATE LEVEL (GRADES 5-8)
ANSWER KEY CONTINUED

(for worksheet on page 11)

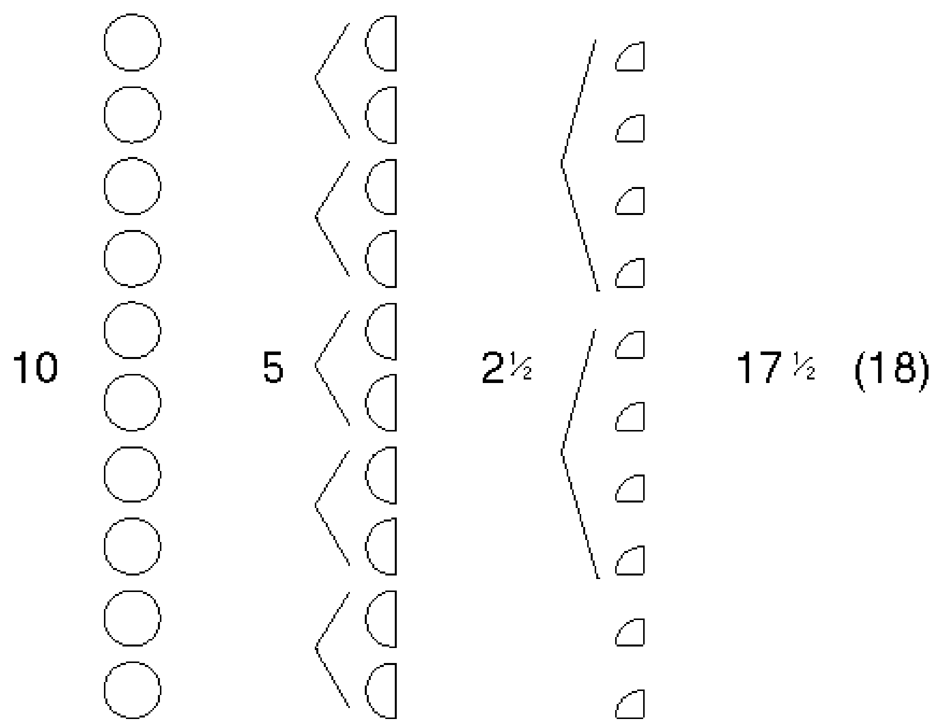
3. List the different ways the results of the experiment might be compared.

   Sample Responses

   - Compare mean vs median of 1/4, 1/2, and 1 tablet
   - Compare means and medians of averaged vs. rounded time
   - What about different brands of seltzer?
   - What if you used A) twice the amount of tablets B) more water C) a bigger container D) different temperatures E) 3/4 tablet F) different shape container G) compare amount of fuel left

4. Draw a diagram to illustrate your answer to the given situation:

> *Suppose that we want to do 10 rocket launches using whole tablets, 10 launches using 1/2 tablets, and 10 launches using 1/4 tablets. How many tablets do we need for our investigation?*



NASA's Education Program is guided by its **Strategic Plan for Education** and is carried out through its nine field centers and the Jet Propulsion Laboratory.

Education programs are grouped into six general categories:

- Teacher/Faculty Preparation and Enhancement Programs
- Curriculum Support and Dissemination Programs
- Support for Systemic Change
- Student Support Programs
- Educational Technology Programs
- Mission, Research and Development, and Operations Programs

NASA Education Link:

http://www.hq.nasa.gov/education

NASA Langley Office of Education Web Site:

http://edu.larc.nasa.gov/

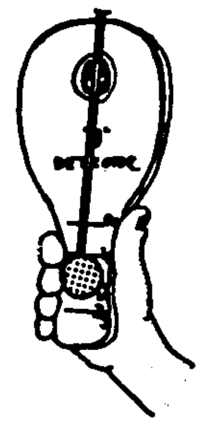
FURTHER EXPLORATION

1. Complete the *Fizzy-Tablet Rocket* activity contained in Section 4, Appendix C.

   NCTM Assessment Standard: Each team can report its findings and conclusions orally to the class. The oral presentation gives students an opportunity to plan and rehearse a group presentation. Allow students to enhance their understanding of using graphs as a tool for communicating by reporting their findings. Make the assessment an open process by having students help create a checklist as they prepare and rehearse their presentation.

2. **Paddleball G-Detector** (K-4). Here is an activity designed to allow students to discover various g-forces at work on Earth. This activity was adapted from the Young Astronaut Program Adventure Series entitled TOYS THAT TEACH. The Paddleball G-Detector can be a fun family activity to determine where people feel heavier and lighter than normal.

   A paddleball can be used to measure the forces you feel. Cut out the paddleball pattern drawn on page 25. Glue the pattern to the side of the paddle where the ball is not attached. Push a tack into the top of the paddle. Hang the ball from the tack by attaching the string to the tack. Fix the string's length so that the ball hangs just in front of the 1g circle. Your g-detector is now complete.

   Hold it in front of you. As you stand still on the earth's surface, you feel a 1g force. That is what your paddleball reads. Can you think of places where your paddle force detector would not read 1g?

   Challenge students to use their g-detector to show the changing forces at different locations, such as in an elevator (as it starts up, stops going up; starts down, stops going down), in a car (bumpy roads, up / down a hill), and at the playground (swing, merry-go-round, seesaw, or on a slide). Where did they find the strongest forces? (*Remember to stress safety precautions to students.*)

3. **Marble Roller Coaster** (5-8). This activity has been adapted from the Virginia Space Grant Consortium product "Journey Into Cyberspace" (http: / / careerjourney.vsgc.odu.edu).
   Divide students into groups of four or five. Explain that each group represents a roller coaster design company and each group hopes to be hired by an area theme park to build a new roller coaster. The park owners are interested in building a good coaster that provides death-defying thrills while being completely safe. The owners also want to know the top speed for the coaster. (*Review the concept of speed and the forumla:* ***Speed = distance/time****. See Computing Coaster's Top Speed on page 18.*)

   The park owners want to see a model of the roller coaster before deciding whether or not to award a contract to a company. Demonstrate to the class how to use the pipe insulation (*See*

Materials) to construct roller coaster tracks. Each group will receive four sections of track which they can tape together. Allow students one day to practice and plan and another day to build and test their coaster design. Have each company demonstrate its coaster to the class. (*See Company Presentation*.)

Materials

1. Obtain approximately 15 lengths of pipe insulation, available at most hardware chain stores at a cost less than one dollar each. Pipe insulation comes in six foot lengths. A one-inch diameter works well. The insulation is precut on one side.
2. Cut each piece in half by slicing directly across from the precut side. This material will provide roller coaster track for a class of 25 students.
3. Additional materials include marbles (30), masking tape (several rolls), crayons, stopwatches, and tape measures.

Management Tips

1. This activity will require several class periods. Students will explore, brainstorm, and sketch during the first period. In the second period, student teams will build the coaster, compute the coaster's top speed, and demonstrate its operation to the class.
2. Your role is that of facilitator. Monitor students' activities and encourage and allow exploration to occur. If possible, video tape each design company's final presentations.

Computing Coaster's Top Speed

1. Choose the location where the marble travels fastest.
2. Using tape, mark a ten foot section at this location.
3. Obtain a stopwatch and time the marble as it passes through this location. Repeat this at least 3 times and compute the average time.
4. Find the speed. Divide the distance (10 ft.) by the time. This is the top speed in feet per second.
5. Multiply this figure by 0.68 to convert to miles per hour.

Company Presentation

Have each presentation include the following information:

1. Coaster's name
2. Description of Coaster's most unique feature
3. Coaster's top speed
4. Four reasons why the theme park owners should buy the coaster design

4. **Exploring Speed**. Three activities are presented here which investigate different aspects relating to the concept of speed. Speed = Distance / Time

Activity 1: Canned Speed (K-4)

Objective: Students use time and distance to investigate speed
Materials: masking tape, marker, meterstick
Procedures:
1. Practice counting to five seconds. It takes about one second to

say “one thousand one,” so count to five this way to measure five seconds.

2. Choose a person to count. Start walking from the start line when the counter says, “one thousand one.” Stop walking when the counter says, “one thousand five.”
3. Repeat Step 2 but hop this time. Repeat again but skip this time.
4. Repeat Steps 2 and 3 for each team member.
5. Which way of moving got each of you the farthest in five seconds? Suppose that you tried the experiment again with one change: you marked off a distance and traveled the whole distance by each way of moving. How could you tell which way of moving was the fastest?

Activity 2: Faster than a Speeding Bullet [Grades 3-5]

Objective: Students will investigate ways to speed up and slow down objects.
Materials: 6 hardcover books, board (about 1m long), masking tape, watch with second hand, marker, tennis ball
Procedures:

1. Find a clear, smooth floor. Make a ramp by stacking two books and propping one end of the board on top of them.
2. Put a piece of tape on the floor at the bottom of the ramp. Label the tape “Start.” Place a second piece of tape two meters (m) away and label it “Finish.”
3. Roll the tennis ball down the ramp. Have a teammate start timing when the ball reaches the Start line and stop when the ball reaches the Finish line. Do three trials. Record the times on your record sheet after each trial.
4. Find the average roll time of the tennis ball at this ramp height.
5. Add two more books to the stack under the top of the ramp. Repeat Steps 2 and 3.
6. Add two more books to the stack . Repeat Steps 2 and 3. Does a change in the ramp’s height change the roll time of the tennis ball? Explain your answer.

Activity 3: Marvelous Marble Mazes [grades 6-8]

Objective: Students will investigate how speed and direction work together.
Materials: 5 or 6 books, board (about 50 cm long), meterstick, masking tape, marble, ball bearing (same size as marble), clay, watch with a second hand
Question to Investigation: Does the weight of a sphere affect its ability to change direction without changing speed?

Procedures

1. Make a record sheet like the one shown below.

	Trials	Distance (in cm)	Time (in sec)	Speed (cm per sec)	Average Speed
Marble Straight Path	1				
	2				
	3				
Marble Curved Path	1				
	2				
	3				
Bearing Straight Path	1				
	2				
	3				
Bearing Curved Path	1				
	2				
	3				

2. Stack books to a height of 20 centimeters (cm). Make a ramp by placing the end of the board on the top book.
3. Roll the clay into two pencil-thin strips the same length as the ramp. Lay the strips straight down the ramp. Put them far enough apart for one of the spheres to roll freely between them.
4. Release the marble at the top of the ramp. Time and record how long it takes to reach the end of the strips. What is the speed of the marble in centimeters per second? Do three trials. Record the average speed.
5. Repeat Step 4 with the bearing.
6. Carefully form the clay strips into the curved track. Is this track the same length as the straight track? How do you know? Repeat Steps 4 and 5 using the curved track.
7. What was the marble's speed on the straight track? The bearing's speed? What was the marble's speed on the curved track? The bearing's speed?
8. Investigate further: Does the number of curves on a track affect a sphere's speed?

5. **Design a Microgravity Experiment**. Have students examine the online video results of a water balloon that was popped in low-gravity environment. Working in teams, have students propose an experiment they'd like to try in a low-gravity environment. Teams should perform the experiment in 1-g and record their results. Next, have them predict what they think would happen to the same experiment performed in a low-gravity (e.g., drop tower or aircraft) environment. (See http://zeta.lerc.nasa.gov/balloon/blob.htm)

6. **Online Projects and Activities**. Explore the following web sites for online projects and activities that connect with the study of human exploration of space and microgravity science:

NeurOn (Neurolab Online) http://quest.arc.nasa.gov/neuron/

Learn how the brain and nerves work in microgravity. Join NASA personnel as they prepare for and conduct the Neurolab mission onboard STS-90 (April 1998). NeurOn uses the Internet and E-mail to help break barriers between NASA and the classroom.

Featured events at this web site are: The Great Habitat Debate, a collaborative activity; Logo Design Contest, a student-team activity to design a logo for the team of scientists with experiments on the mission; Live Interactions with NASA experts and other teachers via WebChat; Student Stumpers, challenging questions relating to the project from students to other students for answering; and NeurOn ExPress, a kid-produced publication to supplement NeurOn.

Space Team Online http://quest.arc.nasa.gov/space

Join the men and women who make the space shuttle fly and learn about their diverse and exciting careers. Peek behind the scenes as these folks train astronauts, prepare the shuttle between missions and then launch it, manage the mission from Mission Control and then bring the shuttle home with a safe landing. Also, meet the people who are making the International Space Station a reality.

S/MORE - Shuttle-MIR Online
Research Experience http://quest.arc.nasa.gov/smore

S/MORE is a K-12 project providing a behind-the-scenes look at the life sciences research conducted in space aboard the Mir station. S/MORE focuses on the men and women doing and supporting this research. The goal is to encourage students'interest in science and technology careers by portraying the NASA experts as friendly people (through biographies and field journals of day-to-day activities). In addition, a special activity highlights the cross-cultural nature of this U.S./Russian effort.

BioBlast http://www.cotf.edu/BioBLAST

NASA's Classroom of the Future has brought together education and biology experts and high school teachers from across the United States to develop a narrow and deep "slice" of biology for high school communities. The six-week curriculum called BioBLAST (Better Learning through Adventure, Simulation, and Technology) will engage students in explorations of the interrelatedness of all living things.

7. **Online Resources for Students and Educators**

Visit the NASA Home Page and Human Exploration and Development of Space Home Page:

NASAHome Page http://www.nasa.gov

NASA Human Exploration and Development of Space Enterprise	http://www.osf.hq.nasa.gov/heds

Check out some of the following NASA Microgravity Web Resources:

NASA Microgravity Research Division Home Page	http://microgravity.msad.hq.nasa.gov
NASA Microgravity Research Program	http://microgravity.msfc.nasa.gov
NASA Microgravity Science Division	http://zeta.lerc.nasa.gov

NASA Education Links:

Classroom of the Future	http://www.cotf.edu
Education Home Page	http://www.hq.nasa.gov/education
Learning Technologies Project	http://learn.ivv.nasa.gov
Liftoff to Space Exploration	http://liftoff.msfc.nasa.gov
Microgravity Research Program Outreach & Education Program	http://microgravity.msfc.nasa.gov/MICROGRAVITY/oeK-12.html
Microgravity Science Division Educational Information	http://zeta.lerc.nasa.gov/new/school.htm
Observatorium	http://observe.ivv.nasa.gov
Spacelink	http://spacelink.nasa.gov

8. **HEDS and Microgravity Educational Products available from NASA Educator Resource Centers (ERC)**

Below are sample educational products available to educators by contacting the NASA ERC that services your region / state:

Teachers Guides Microgravity (EG-1997-08-110-HQ)

The Microgravity Teachers Guide can be downloaded from NASA Spacelink at the following URL address:
http: / / spacelink.msfc.nasa.gov / Instructional.Materials / Curriculum.Materials / Science / Microgravity / Microgravity.Teachers.Guide.6-12

Educational Briefs The Mathematics of Microgravity (EB-118 4 / 96)

Liftoff to Learning Videos
All Systems Go!
Assignment: Spacelab!
Living in Space
Microgravity
Newton in Space
Space Basics
Tethered Satellites
Toys in Space II

Each *Liftoff to Learning* program comes with a printed video resource guide that provides valuable information for teachers, resources for additional study, and practical hands-on demonstrations of some of the concepts presented in the videotapes.

Lithographs
Protein Crystal Growth in Space (Hql-233)
Microgravity Science Research: Space Shuttle Missions Lithograph Set (EP-1997-02-360-HQ)

Poster
Microgravity Research Program(NW-1996-09-147-HQ)

Information Summary
Spacelab (PMS-021, Sept. 1994, MSFC)
The Fourth United States Microgravity Payload (Oct. 1997, MSFC)

Contact information about the NASA ERCs regarding their locations, addresses, and telephone numbers can be found online at
http: / / www.teacherlink.usu.edu / nasa / accessnasa / TRC.html

NASA ERC serving Langley's 5-state service region of KY, NC, SC, VA, and WV:

Virginia Air & Space Center
NASA Langley Educator Resource Center
600 Settlers Landing Road
Hampton, VA 23669-4033
(757) 727-0900, ext. 757

9. Leap into more aerospace science-related mathematics activities from the National Council of Teachers of Mathematics (NCTM) and the new NASA-funded product, *Mission Mathematics, Linking Aerospace with the NCTM Standards*.

   Mission Mathematics:

   • integrates mathematics and science following the guidelines of the NCTM standards

   • motivates students to explore math and develop mathematical thinking

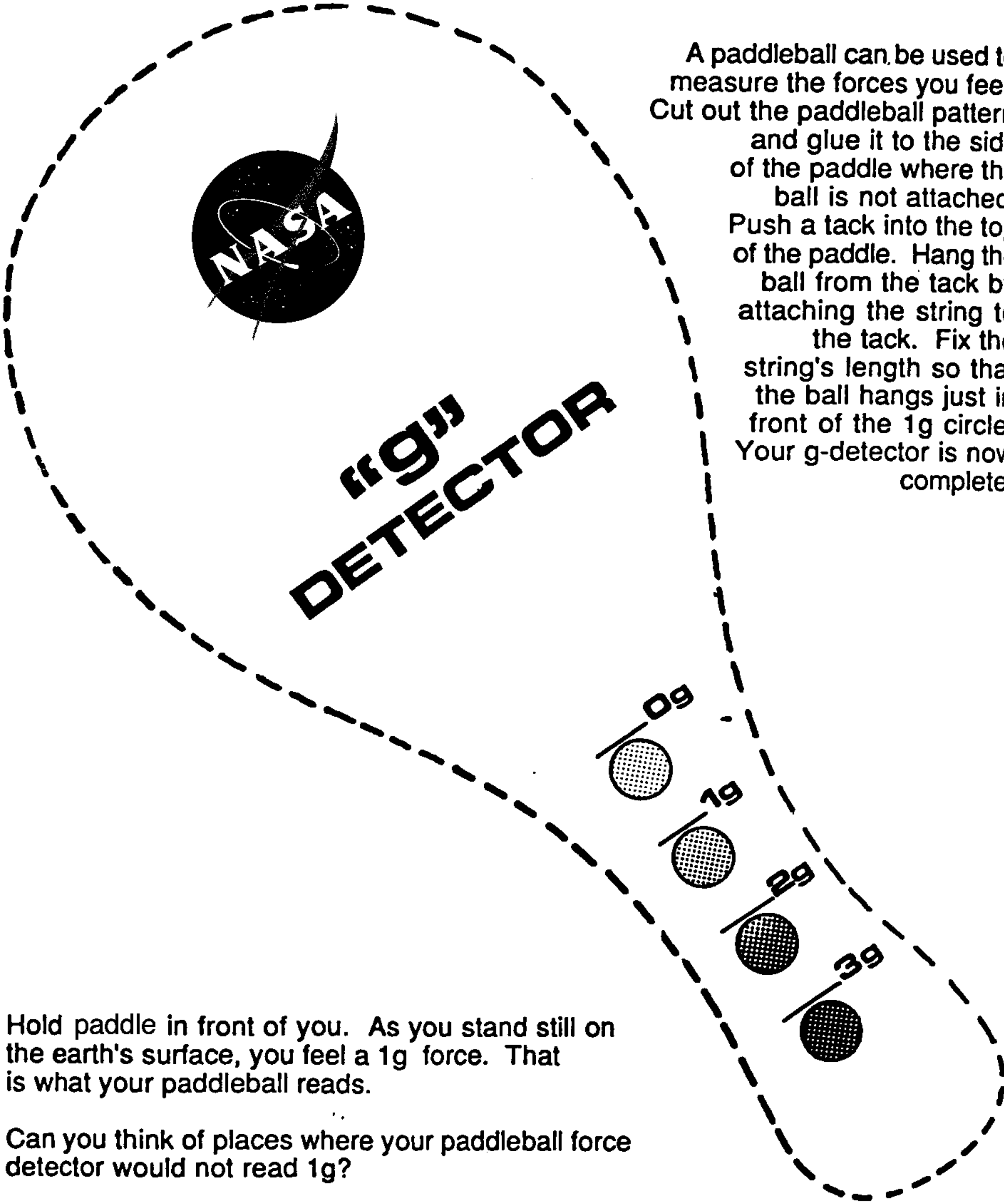
   • features activity books and posters for K-6, 5-8, and 9-12

   Contact the NCTM, 703/620-9840, for more information, or visit their web site at http://www.nctm.org/

10. **Neurolab Education Program**. The Morehouse School of Medicine Neurolab Education Program, in cooperation with NASA Life Sciences Division, is developing a neuroscience curriculum supplement for grades 6-12 in celebration of the (April) 1998 Neurolab shuttle mission. The Neurolab science payload will examine the effects of weightlessness and other aspects of the space environment on the nervous system.

    A **Teacher's Guide** has been prepared and is further supplemented with a **CD-ROM** that lets students discover the Neurolab experiments at their own pace. For further information, contact the Morehouse School of Medicine Neurolab Education Program at 404/756-5705, or send an E-mail message to thomast@link.msm.edu

Paddleball g-Detector Pattern



A paddleball can be used to measure the forces you feel. Cut out the paddleball pattern and glue it to the side of the paddle where the ball is not attached. Push a tack into the top of the paddle. Hang the ball from the tack by attaching the string to the tack. Fix the string's length so that the ball hangs just in front of the 1g circle. Your g-detector is now complete.

Hold paddle in front of you. As you stand still on the earth's surface, you feel a 1g force. That is what your paddleball reads.

Can you think of places where your paddleball force detector would not read 1g?

APPENDIX A

Appendix (A1–A8)

NASA Microgravity Web Sites

NASA Lewis Research Center Microgravity Science Division
http://zeta.lerc.nasa.gov

NASA Marshall Space Flight Center Microgravity Research Program
http://microgravity.msfc.nasa.gov

Microgravity Science and Applications
http://microgravity.msad.hq.nasa.gov

The following density activity will allow your students to prepare for the CONNECT program *Doing More in Less.* The activity will introduce the concepts of gravity, microgravity, and density and will give students practice graphing activity results and reasoning mathematically.

The K-4 and 5-8 activity includes both worksheets and answer keys to support the educator's implementation and discussion with students.

Contributor Melissa Rogers, National Center for Microgravity Research on Fluids and Combustion, has supported the development of additional NASA educational products including the *Microgravity Teachers Guide* listed in Section 3, Further Exploration.

PRE-PROGRAM PREPARATION ACTIVITY

1. Discuss the states of matter. Vocabulary: solid, fluid, liquid, gas. Students should be able to give examples of each.
2. Discuss what happens when an object falls on Earth. Vocabulary: gravity, free fall, acceleration, distance, elapsed time. Students should develop an appreciation for the relationship between the terms listed.
3. Discuss some of the effects of gravity. Vocabulary: actual weight, apparent weight, density, sedimentation (settling), density-driven convection, microgravity. Students should realize that gravity causes the separation of matter of different densities.

Fairly simple line art could be developed for teaching tools for these discussions.

Discussion Questions

1. Where do scientists perform microgravity experiments?
2. What type of science experiments are done in microgravity?
3. How is mathematics used in microgravity research?

CLASSROOM EXPERIMENT K-4

Activity Overview

Students working in teams (at least 3 per team) will investigate relative densities of different objects.

Activity Purpose

Understand that matter exists in different states. Observe similarities of and differences between objects. Measure the volume of a liquid. Understand that a force called gravity pulls objects down towards the center of Earth (and pulls any two masses together). Understand that objects of different density can be classified based on their relative density compared to a standard. Display scientific data in a graphical representation.

Activity Procedure

During a discussion of gravity, several solid objects should be dropped so that they fall to the floor. Then water should be “dropped” into a measuring container, leaving enough room in the container for additional objects. The students should record the volume of the water. The remainder of the activity can be done as a demonstration for an entire class, or students can be separated into small groups and allowed to work at separate stations with containers of water and several objects. A series of objects should be dropped individually into the water in the container (the objects should include a penny, a wood block, an ice cube, and several unknown objects of different size). The students should record their observations in the first table and then complete the worksheet.

CLASSROOM EXPERIMENT 5-8

Activity Overview

Students working in teams (at least 3 per team) will measure the masses of different objects. The students will estimate the volume of the objects and compute average densities for the objects. After determining whether the objects sink or float in water and knowing the density of water, the students will decide whether their estimated densities are reasonable.

Activity Purpose

Understand that matter exists in different states. Observe similarities of and differences between objects. Measure the volume of a liquid. Measure the mass of solids. Estimate volume of solids using simple measurement tools and equations. Display scientific data in a graphical representation. Understand that a force called gravity pulls objects down towards the center of Earth (and pulls any two masses together). Understand that objects of different density can be classified based on their relative density compared to a standard.

Activity Procedure

During a discussion of gravity, several solid objects should be dropped so that they fall to the floor. Then water should be “dropped” into a measuring container, leaving enough room in the container for additional objects. The students should record the volume of the water. The remainder of the activity can be done as a demonstration for an entire class, or students can be separated into small groups and allowed to work at separate stations with mass balances, containers of water, distance measuring scales, and several objects. A series of objects should be dropped individually into the water in the container, their masses should be measured, and their volume estimated (the objects should include a penny, a wood block, an ice cube, and several unknown objects of different size). The students should record their observations in the tables and then complete all but the final question of the worksheet.

Following the density computations, show the class an “executive toy” with different density immiscible fluids in it. Discuss the behavior of the liquids. Have the students complete the last question of the worksheet. Discuss the students’ hypotheses.

EXTENSION ACTIVITY: GRADES 5-8

Activity Overview

Students working in teams (at least 3 per team) will drop two plastic soda bottles (one empty, one filled with colored water) from one height several times each and record the drop times (from release to impact on ground). Using the time and distance (drop height) data collected and some supplementary information, the students will figure out the functional relationship among acceleration, distance, and time. A follow-on activity involving punching holes in the filled bottles will allow the students to hypothesize about what happens when an experiment is put into free fall.

Activity Purpose

Observe similarities of and differences between objects. Perform distance and time measurements using appropriate tools. Understand the limitations of measurement devices. Use scientific data to reason out functional relationships among parameters. Develop teamwork skills. Understand that a force called gravity pulls objects down towards the center of Earth (and pulls any two masses together). Appreciate that putting an experiment into free fall has an effect on the interactions between the parts of the falling experiment.

Activity Procedure

For the drop part of the activity, there should be at least three team members: one will release the object, one will time the drop, and one will record the data. If three drops are made of each object, each team member will be able to assume each role. One student will hold one of the objects at the level of the mark, and after assuring that the other team members are ready, will release the object and say “Start”. The timer will start the stopwatch when given the “Start” command. The data recorder will watch the dropped object and will say “Stop” when the object hits the ground. The timer will stop the stopwatch when given the “Stop” command. The data recorder will enter the elapsed time for the drop in the appropriate location on the data sheet. This procedure should be done three times for each object.

The data collected should be used in concert with the information provided on the data sheet to figure out the functional relationship among acceleration, distance, and time. The team members should also discuss the questions asked on the worksheet and record their answers.

Following the initial drop experiments, bottles with holes punched out of the side near the bottom should be filled with colored water. The students should discuss within their teams what will happen if the hole is uncovered. Their answers should be recorded on the worksheet and the experiment performed. Then the students should discuss what would happen if the filled bottle with the hole in it were dropped. Their answers should be recorded on the worksheet and the experiment performed. A discussion of the results of the experiment should be held with all the teams.

K-4 CLASSROOM SINK AND FLOAT EXPERIMENT WORKSHEET

Team Members:

What is the volume of water that was dropped into the container?

Mark whether the object floated or sank.

Penny _______________ Wood Block _________ Ice Cube _____________
Unknown 1 ___________ Unknown 2 ___________ Unknown 3 ___________

How many objects were dropped into the measuring container? ___________

How many things floated? ___________

How many things sank? ___________

The average density of water is 1 gram per cubic centimeter. Objects that are less dense than water float. For each object, indicate whether the density is greater than or less than 1 gram per cubic centimeter.

Penny _______________ Wood Block _________ Ice Cube _____________
Unknown 1 ___________ Unknown 2 ___________ Unknown 3 ___________

Display the density data on a bar graph.

Record some things you noticed about the different objects that were dropped.

____

____

Did whether an object floated or sank depend on the size of the object? Explain.

____

____

K-4 CLASSROOM SINK AND FLOAT EXPERIMENT WORKSHEET

ANSWER KEY

Team Members:

What is the volume of water that was dropped into the container? **1/2 Liter**

Mark whether the object floated or sank.

Penny **sank**	Wood Block **floated**	Ice Cube **floated**
Unknown 1 (wine bottle cork) **floated**	Unknown 2 (quartz crystal) **sank**	Unknown 3 (balsa wood) **floated**

How many objects were dropped into the measuring container? **7 (includes water)**

How many things floated? **4**

How many things sank? **2**

The average density of water is 1 gram per cubic centimeter. Objects that are less dense than water float. For each object, indicate whether the density is greater than (>) or less than (<) 1 gram per cubic centimeter.

Penny **>1 g/cc**	Wood Block **<1 g/cc**	Ice Cube **<1 g/cc**
Unknown 1 **<1 g/cc**	Unknown 2 **>1 g/cc**	Unknown 3 **<1 g/cc**

Display the density data on a bar graph.

Did whether an object floated or sank depend on the size of the object? **No**

5-8 CLASSROOM SINK AND FLOAT EXPERIMENT WORKSHEET

Team Members:

What is the volume of water that was dropped into the container?

Mark whether the object floated or sank.

Penny _______________ Wood Block _________ Ice Cube _____________

Unknown 1 ___________ Unknown 2 ___________ Unknown 3 ___________

Measure and record the mass of each object.

Penny _______________ Wood Block _________ Ice Cube _____________

Unknown 1 ___________ Unknown 2 ___________ Unknown 3 ___________

Estimate the volume of each object.

Penny _______________ Wood Block _________ Ice Cube _____________

Unknown 1 ___________ Unknown 2 ___________ Unknown 3 ___________

Estimate the average density of each object. Average density is equal to the ratio of the mass of an object to its volume.

Penny _______________ Wood Block _________ Ice Cube _____________

Unknown 1 ___________ Unknown 2 ___________ Unknown 3 ___________

The average density of water is 1 gram per cubic centimeter. Objects that are less dense than water float. Using this information, determine whether the average densities you estimated are reasonable.

Display the density data on a bar graph, including the water. Note that the density of water given above was for 4 °C. The density of water at 20 °C is 0.9982 g/cc. Use this information when constructing the bar graph.

Did whether an object floated or sank depend on the size of the object?

What role, if any, does gravity play in this experiment?

5-8 CLASSROOM SINK AND FLOAT EXPERIMENT WORKSHEET
ANSWER KEY

Team Members:

What is the volume of water that was dropped into the container?

Penny **sank**	Wood Block **floated**	Ice Cube **floated**
Unknown 1 (wine bottle cork) **floated**	Unknown 2 (quartz crystal) **sank**	Unknown 3 (balsa wood) **floated**

Measure and record the mass of each object.

Penny _______________ Wood Block _________ Ice Cube _____________

Unknown 1 ___________ Unknown 2 ___________ Unknown 3 ___________

Estimate the volume of each object.

Penny _______________ Wood Block _________ Ice Cube _____________

Unknown 1 ___________ Unknown 2 ___________ Unknown 3 ___________

Estimate the average density of each object. Average density is equal to the ratio of the mass of an object to its volume. **Actual values listed.**

Penny: **(copper) 8.9 g/cc**

Wood Block: **0.1–0.8 g/cc** *depending on type. Note that some wood has a density >1 g/cc.*

Ice Cube: **0.92 g/cc**

Unknown 1: **0.22-0.26 g/cc**

Unknown 2: **2.6 g/cc**

Unknown 3: **0.11–0.14 g/cc**

The average density of water is 1 gram per cubic centimeter. Objects that are less dense than water float. Using this information, determine whether the average densities you estimated are reasonable.

Display the density data on a bar graph, including the water. Note that the density of water given above was for 4 °C. The density of water at 20 °C is 0.9982 g/cc. Use this information when constructing the bar graph.

The water should be included in the 0-1 g/cc bar.

Did whether an object floated or sank depend on the size of the object? **No**

What role, if any, does gravity play in this experiment?

It is because of gravity that the more dense objects settle to the bottom of the container. If gravity were not present, an object with density greater than 1 g/cc released in the center of the container of water would stay in that position. Of course, it would have to be a closed container completely filled with the water. If gravity were not present, the water would not have poured into the container and filled the bottom of it as on Earth.

5-8 EXTENSION ACTIVITY WORKSHEET

Team Members:

Enter the data values from the video.

Drop Height = (meters)	Object #1	Object #2
Drop Time= (seconds)	t11=	t21=
Drop Time= (seconds)	t12=	t22=
Drop Time= (seconds)	t13=	t23=

Object #1

Calculate Average Drop Time: t1avg =

The average of a set of values is equal to the sum of the values divided by the total number of values

Object #2

Calculate Average Drop Time: t2avg =

Using the average drop time data and the additional information provided below for two Microgravity Research Drop Facilities at NASA Lewis Research Center, what equation can you write that shows the functional relationship among acceleration, distance, and time?

At the Zero-g Facility at Lewis Research Center, a 132 meter drop takes 5.2 seconds.

At the 2.2 Second Drop Tower at Lewis Research Center, a 24 meter drop takes 2.2 seconds.

If you need another data point, consider an object at rest on Earth's surface. Why is such an object appropriate data point?

The average acceleration due to gravity at Earth's surface is 9.8 m/s2.

Questions:

What differences do you observe between the two objects you dropped?

What errors are there in your distance and time measurements?

How could you improve your measurements?

What would happen if one of the filled bottles had a hole punched in its side near the bottom?

What would happen if you dropped the bottle with the hole in it?

APPENDIX B

Appendix (B1–B3)

µg*

*The graphic µg represents microgravity. The µ is the Greek symbol for the lower case letter m (for micro), and g is a scientific abbreviation for gravity.

The following section gives introductory information on microgravity and gravity.

Help students obtain a working understanding of the concepts of gravity and microgravity. Copy and distribute articles to students, as appropriate for the class. Distribute several blank 5 1/2 x 7 inch index cards per student.

Working with students, read aloud each paragraph in an article and discuss. Next have students illustrate, on an index card their understanding of the paragraph. Continue until the article has been read and illustrated.

Finally, have students cut apart the article into paragraphs and reassemble with their illustrations into Gravity and Microgravity booklets.

Gather students into small groups to share and discuss their interpretations of the article and their understanding of the concepts of gravity and microgravity.

What is Microgravity?

Microgravity is a term commonly applied to a condition of free fall within a gravitational field in which the weight of an object is reduced compared to its weight at rest on Earth. Microgravity means small or reduced gravity.

Microgravity can be created in two ways. One way is to travel far away from Earth, since gravitational pull diminishes with distance; but to reach that point, you would have to travel out into space a distance of 6.37 million kilometers (17 times farther away than the Moon).

A second, and much more practical method, is creating the microgravity environment through the act of free fall. To illustrate how free fall can achieve a state of near weightlessness (or microgravity) during Shuttle flight, imagine riding an elevator car to the top of a very tall building. At the top, the cables supporting the car break, causing the car and you to fall to the ground. Since you and the elevator are falling together you will "float" inside the car. In other words, you and the elevator car are traveling downward at the same rate. When orbiting Earth, a spacecraft and the crew (like the rider in the elevator) is in this condition of continuous free fall, and thus, is in microgravity.

Sir Isaac Newton offered a thought-provoking experiment to explain how an object could stay in an orbit while falling toward the Earth. He imagined a cannon at the top of a tall mountain that fired cannonballs starting out on a straight line parallel to the ground. Each cannonball was acted upon by two forces. The force from the explosion propelled the cannonball in a straight line at a constant velocity. The force of gravity would pull the cannonball down toward the Earth. The combination of the two forces would cause the cannonballs to travel in an arc ending at the Earth's surface.

If the cannonballs were fired with more and more energy, they would hit the ground farther and farther away from the cannon. If the cannonball was fired with enough energy, it would fall entirely around the Earth and return to its starting point, completing an orbit.

This cannonball analogy shows how the Space Shuttle stays in orbit above the Earth. Instead of being fired from a cannon atop a mountain, the Shuttle is launched in a trajectory that arcs above Earth. It gradually curves away from a vertical path until it is flying parallel to the ground outside of Earth's atmosphere. Using its engines, the Shuttle attains an altitude of around 320 km (200 miles) above the planet's surface. After the engines stop, the Shuttle is traveling at a speed of about 7.5 km (4.7 miles) per second. At this speed and altitude, the Shuttle's falling path will be parallel to the curvature of Earth. Because the Shuttle is free-falling around the Earth, a microgravity environment is established.

This microgravity environment gives researchers a unique opportunity to study the fundamental states of matter: solids, liquids, and gases, and the forces that affect them. In microgravity, researchers can isolate and control these forces. Obtaining scientific results from the microgravity experiments allows studies of the influence of gravity on physical processes, as well as other phenomena, which are normally masked by gravity's effects and are difficult, if not impossible, to study on Earth.

The use of space as a laboratory for conducting research is an extremely challenging endeavor with tremendous scientific, educational, and societal value. To give astronauts a preview of the weightlessness they will experience in space, NASA uses a modified KC-135 four-engine jet transport. By flying a parabolic course, the aircraft can create short periods of weightlessness for the astronauts in the cargo bay. During these moments the astronauts can practice eating, drinking, and using various kinds of onboard Shuttle equipment. Training sessions in the KC-135 (affectionately known as the "Vomit Comet") normally last from 1 to 2 hours.

µg

The Story of Gravity

Although the fundamental principles of gravity eluded scientists throughout history until Sir Isaac Newton first described it quantitatively in 1687, the effects of gravity are part of our everyday experience. Gravity keeps our feet planted on the ground, returns an apple thrown high into the sky back to Earth, and pulls spilled milk toward the floor. Without gravity, the very air we breath would dissipate into space, and Earth would not orbit the Sun.

Gravity is one of four fundamental forces in the universe (the other three are the electromagnetic force, the strong nuclear force, and the weak nuclear force). Newton's Law of Universal Gravitation states that all bodies attract each other, and that the force of this attraction between any two bodies depends on 1) the mass of both bodies and 2) the distance between them. Specifically, the gravitational attraction between two bodies is directly proportional to the product of their masses (double the mass, and the force doubles) and inversely proportional to the square of the distance between the centers of two bodies (double the distance, and the force decreases by a factor of two squared, or four).

The Earth is a large mass that exerts a strong gravitational pull toward its center on all nearby bodies–according to the other object's mass and distance from the center of the Earth. This mass includes all things on the surface of the Earth, the Moon, orbiting spacecraft, and (to a much lesser degree because of the distance) other celestial bodies. According to Newton's law of gravity, then, the Earth exerts a greater gravitational force on objects with greater mass, such as a piano, and less force on an object such as a saxophone. That is why a piano weighs more than a saxophone on a scale: weight, by definition, is the gravitational force with which the Earth attracts a body. It is important to note that weight is a force and therefore different from mass: a body's mass doesn't vary with its location, but its weight will lessen, for example, as it is moved away from the Earth.

Intuitively, then, we might expect a piano to "fall faster" than a saxophone if both were dropped from the Empire State Building. That is, in fact, what many scientists believed until Galileo demonstrated that all objects dropped simultaneously from the same height will hit the ground at the same time no matter what their mass. The acceleration of all bodies near the Earth's surface (how fast their speed increases as they fall) is the same: approximately 9.8 meters (32 feet) per second. How can this principle be explained?

Return for a moment to the concept of mass. The practical way to determine an object's mass is to weigh it on a scale. The weight, as mentioned above, depends on the object's gravitational mass. A piano on the moon, however, would weigh less–even though its mass remains unchanged. Newton's Second Law of Motion provides a different concept of mass which is independent of gravity: inertial mass. Place the piano and the saxophone each on a cart and apply the same external force to both–a good shove to move them across the floor. The resulting accelerations will not be the same: the cart with the saxophone will move farther. The extent to which a body at rest will yield to an external force depends upon its inertial mass: if the mass is large (as in the case of the piano), the resistance to the motion will be greater than if the mass is small (as with the saxophone).

Thus, although gravity may act with relatively more force on the piano than on the saxophone (according to the gravitational mass of each), the piano's resistance to this force (its inertial mass) is also greater. In fact, Galileo's experiments demonstrated that since all objects–regardless of their mass–fall with the same acceleration, gravity's "pulling" force on an object must be equal to the object's resistance. Galileo's experiments (and subsequent research) thus provide evidence for what scientists call the equivalence principle: that gravitational mass and inertial mass are equal. This classical description of the equivalence principle formed the foundation of Einstein's general theory of relativity. Contemporary research, however, has raised fundamental questions about the nature of gravity and may go beyond Einstein's theory of gravity and the equivalence principle.

Appendix C

Fizzy-Tablet Rocket

Classroom Experiment

Self-Contained Lesson

The following lesson plan will allow your students to duplicate the experiment that was shown during *Doing More In Less*, Program 4 of the CONNECT Series. Copies of the video can be made at the NASA Langley Educator Resource Center.

Nick Kolten, ERC Manager
Virginia Air & Space Center
NASA LaRC ERC
600 Settlers Landing Road
Hampton, VA 23669-4033
(757) 727-0900, ext. 757
http://www.vasc.org/erc/

INTRODUCTION

NASA seeks to answer fundamental questions about the universe. NASAscientists often wish to escape the ever present constraints of Earth's gravity and atmosphere. Free from the confines of gravity, they can impose precise conditions on experiments to learn more about these phenomena and how they can be controlled.

This microgravity environment gives researchers a unique opportunity to study the fundamental states of matter: solids, liquids, and gases and the forces that affect them. In microgravity, researchers can isolate and control these forces. Obtaining scientific results from the microgravity experiments allows studies of the influence of gravity on physical processes, as well as other phenomena which are normally masked by gravity's effects and are difficult, if not impossible, to study on Earth.

In this lesson students will explore the concept of microgravity. By working in pairs or small groups, they will better understand how research teams of NASA engineers, scientists, and technicians must work together to conduct investigations.

Students will launch film-canister rockets to investigate the effects of varying the amount of fuel (fizzing antacid tablets) to the difference in time from fuel ignition to landing. They will actually observe and collect data to see whether there is a difference in time from fuel ignition to landing. Three different amounts of fuel are tested: one whole tablet, one 1/2 tablet, and one 1/4 tablet. The amount of water in the canister remains constant at one tablespoon.

PURPOSES

For all students:

- To develop number sense for, and concepts of, fractions and mixed numbers
- To use two standard units of measure, tablespoons and seconds
- To collect, organize, analyze, and interpret data
- To work cooperatively in teams

For intermediate students:

- To use rounding to relate decimal values to whole numbers
- To find the median and mean of a set of data
- To use estimation to determine the reasonableness of sums found with a calculator

NCTM MATHEMATICS STANDARDS

- Fractions and Decimals
- Number Sense and Numeration
- Patterns and Relationships
- Statistics and Probability
- Measurement

NCTM ASSESSMENT STANDARDS

- Talking and writing about predictions and interpretation of data help students confirm their learning
- Observe which students can use a data-collection form and which students need to learn how

INSTRUCTIONAL OBJECTIVES

- Collect, organize, analyze, and interpret data
- Use standard unit of measure (seconds)
- Work cooperatively in pairs/teams

PREREQUISITE MEASUREMENT AND GEOMETRY CONCEPTS

Students in grades 5–8 should be able to

- Use rounding to relate decimal values to whole numbers
- Find the mean and median for a set of data

EXPERIMENT MATERIALS

Clear plastic film canisters, fizzing antacid tablets, water, one-tablespoon measuring device, digital stopwatch or other timing device to measure seconds

PRINT MATERIALS

Microgravity Data Sheet

MANAGEMENT TIP

This activity can extend over several instructional periods.

SAFETY TIP

Be sure that students waiting for liftoff stand back after the canisters have been placed upside down. Rockets usually fly a maximum of 3 to 4 feet. Use caution, especially with the 1/4-tablet launches. You do not want liftoff to

occur while someone is looking down on the canister!

BEFORE THE ACTIVITY

Ask a local processor to save clear plastic film canisters, not the black ones. Most processors are happy to do so. The lids on the clear canisters fit inside the rim rather than over the side. This fit makes a tighter seal and allows more time for the pressure to build up inside the canister, thus producing a better rocket.

Precut the antacid tablets into halves and quarters by scoring the tablet with a serrated knife and breaking it on the line.

The following experiment will emphasize experimentation with one variable, fuel amount. Students will examine the relationship of the tablet size (fuel) to the "rocket's" flight time. The constant in the experiment will be the amount of water added to the film-canister rockets. The changing (independent) variable will be the amounts of fuel tested: one whole tablet, one 1/2 tablet, and one 1/4 tablet. Students will work with trial data to examine the differences in flight times and make comparisons and predictions.

Students in grades 5-8 will round the flight time data to the nearest whole number and will then be asked to compute the mean and median for the data. Number sense and numeration, measurement, statistics and probability, patterns and relationships, and fractions and decimals will be emphasized.

Make copies of the Microgravity Data Sheet and distribute one to each student prior to the experiment.

GETTING STARTED

Prepare the tablets; students should see the process of dividing the tablets into the fractional parts. Demonstrate how two 1/2 pieces combine to equal a whole. Prompt students to investigate to find other relationships by asking them how many 1/4 pieces combine to equal a 1/2 piece and how many 1/4 pieces combine to make a whole.

VOCABULARY TERMS

- **acceleration -** the rate at which an object's velocity changes with time
- **gravity -** the attraction of all objects to one another due to their mass
- **mass -** a measurement of a body's weight that takes into account its resistance to movement
- **microgravity -** the condition of free fall within a gravitational field in which the weight of an object is significantly reduced compared to its weight at rest on Earth
- **weight -** the measure of the object's resistance to gravity

CLASS DISCUSSION

List the following questions on the board. Have students discuss the questions.

1. What is gravity? Microgravity?
2. When have you experienced microgravity?
3. Does the term "zero gravity" mean the same thing as "microgravity"? Is it correct to say that the astronauts are in zero gravity when in space?

DEVELOPING THE ACTIVITY

Depending on the maturity level of the students, the experiment can be done as a whole class or by dividing the students into teams.

Grades K-4

Follow these directions to launch the rocket.

Put one tablespoon of water into a film canister. One student places a 1/4 tablet into the canister, quickly closes the lid tightly, and places the canister upside down on a level surface. As the tablet is placed in the water, the students call out to the timer, "Start!"

A different student is nearby with a stopwatch. The stopwatch is started when the tablet is dropped into the water in the canister. When the rocket hits the ground at the end of its flight, the timer stops the stopwatch.

Help students measure and record the number of seconds it takes for each flight from ignition to landing. You may use a large class chart to record the times for the launches or have the students record the times on their individual data sheets.

Repeat the trial 3 times for each tablet size to allow students to see a pattern emerge. The 1/4 tablets take the longest, the 1/2 tablets fall in a middle time range, and the whole tablets are the fastest.

Grades 5-8

Follow directions as outlined above by using teams. However, the mathematics used and the tasks and problems presented are more advanced. Students are to complete the Data Sheet by rounding the flight times of each entry. They are also to calculate the mean and median flight time for each tablet strength.

CLASS DISCUSSION

Grades K-4 Questions

- Which tablet size took the longest time from ignition to landing?
- Which tablet size was the fastest from ignition to landing?
- Compare the flight time for two 1/4 pieces and the time for one 1/2 piece. Are they about the same? Why?
- Predict what would happen to the flight time if two 1/2 tablet pieces were put in a canister. How would this flight time compare to the time for the one whole tablet?
- Should we record the times for two 1/2 tablets and the times for whole tablets in the same column on the data sheet? Why?

Grades 5-8 Questions

- Which tablet took the longest time from ignition to landing?
- What are the different ways the results of the experiment might be compared?
- Why do you think the 1/4 tablet took consistently longer from ignition to landing?
- Suppose that we want to do ten rocket launches using whole tablets, ten launches using 1/2 tablets, and ten launches using 1/4 tablets. How many tablets do we need for our investigation?

FURTHER EXPLORATIONS

- To explore the equivalency of fractions, try several launches using different combinations, such as placing two 1/4 pieces in a canister to see whether the time is similar to the times for the one 1/2 tablet data. Continue by comparing other equivalencies.
- For a related, but more advanced, problem, ask students this question. What if we want to do the same number of launches with whole tablets, 1/2 tablets, and 1/4 tablets, but we do not want to have any leftover pieces? How many launches should we plan to do in our investigation?

  Record the “addition” sentence and then extend the problem. How many tablets would you need to do eight trials at each strength? (8+4+2=14)

  How many tablets are needed for twelve trials at each strength? (12+6+3=21) What patterns to you see?
- Now that students have a sense of the range of possible times for each tablet size, try a blind launch series. In this activity the launch team decides on four tablet sizes and keeps them secret from the data team. The launch team launches its first rocket and writes the tablet size used on its data sheet as launch A. The data team measures the time from ignition to landing and records it as A on its data sheet. On the basis of the flight time, the data team decides if launch A used 1/4, 1/2, or one tablet and writes the prediction on its data sheet.

  Continue in this manner for launches B, C, and D. At the conclusion of the four launches, the launch team compares its data sheet with the data sheet of the data team to see how closely its predictions match the actual tablet sizes used. The two teams can exchange roles.
- Students may wish to conduct the investigation again using different fuel combinations: Antacid tablets and vinegar or baking soda (1/4 tsp., 1/2 tsp., and 1 tsp.) and vinegar. Compare these results with results from the current investigation. Did different fuel combinations significantly alter flight times?

MICROGRAVITY DATA SHEET
GRADES K–4

Flight Time in Seconds
from ignition to landing

size / trial	(1/4)	(1/2)	(1)
1			
2			
3			

MICROGRAVITY DATA SHEET
GRADES 5–8

Flight Time in Seconds
from ignition to landing

size / trial	(1/4)	(1/2)	(1)
1			
2			
3			

Round the flight times of each entry. *(Hint: Round up to the greater whole number if decimal number is 0.5 or greater.)*

Flight Time in Seconds
from ignition to landing

size / trial	(1/4)	(1/2)	(1)
1			
2			
3			

3-2-1 POP

Description

Students construct a paper rocket to wrap around the film canister rocket powered by the pressure generated from an effervescing antacid tablet reacting with water.

Materials and Tools

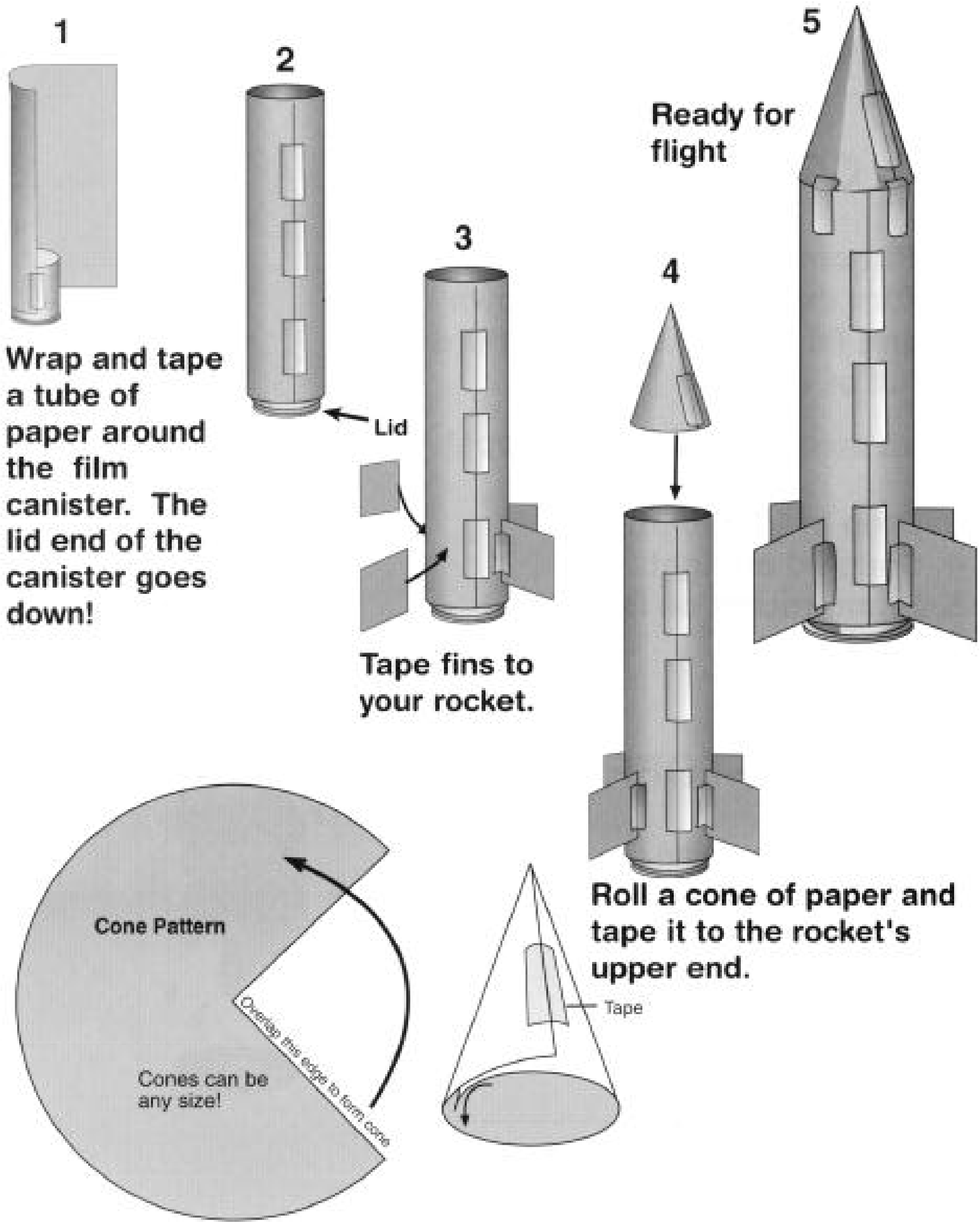
- Heavy paper (60-110 index stock or construction paper)
- Plastic 35 mm film canister (The film canister must have an internal-sealing lid. [see p. C3 "Before The Activity"])
- Student sheets
- Cellophane tape
- Scissors
- Effervescing antacid tablet
- Paper towels
- Water
- Eye protection

Management

A single sheet of paper is sufficient to make a rocket. Be sure to tell the students to plan how they are going to use the paper. Let the students decide whether to cut the paper in the short or long direction to make the body tube of the rocket. The direction will lead to rockets of different lengths for flight comparison.

The most common mistakes in constructing the rocket are forgetting to tape the film canister to the rocket body, failing to mount the canister with the lid end down, and not extending the canister far enough from the paper tube to make snapping the lid easy. To make the cone, cut out a pie shape from a circle and curl it into a cone. Cones can be any size.

“FIZZY TABLET” ROCKET DIAGRAM



Appendix D

Home Connection

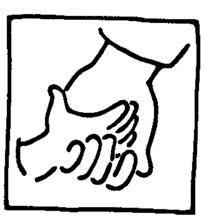
As part of the unique partnerships established through the CONNECT series, NASA Langley's Office of Education has teamed with Langley's Learning Technology Project Office to create a motivational and instructional web-based element that directly ties to the CONNECT mathematics lesson on Fizzy-Tablet Rockets. We have built this activity to be included under the Home Connection element of the program's outreach. Home Connection encourages parents and children to work together as a team in an investigation either prior to or immediately following the televised broadcast.

National Education Goal 8:

By the year 2000, every school will promote partnerships that will increase parental involvement in promoting the social, emotional, and academic growth of children.

The NASA Education Program supports the development of family-centered education projects to help parents become full partners in the education of their children and to be informed, active proponents for high-quality science, mathematics, and technology education in both school and non-school settings.

The Home Connection exercise is designed to give additional support to the math concepts presented in the CONNECT 4 program. Use of the web-based activity is optional. Educators are encouraged to implement the activity in ways which best meet the needs of their students and as dictated by the curriculum.



Educators are encouraged to photo copy and send home with their students the letter on page D2. This letter explains the web-based activity and how families might use it to strengthen their children's mathematics skills, in addition to preparing or reinforcing with the children the concepts addressed in the CONNECT *Doing More In Less* program.

To support the NASA Strategic Plan and NASA's Educational Technology Program, the LTP researches emerging technologies and then develops these technologies into high-quality and affordable learning environments connecting educators with NASA missions.

In collaboration with the Langley Office of Education, we have created an online presence for NASA's missions. Our work is intended to enhance the content knowledge, skills, and experience of teachers, capture the interest of students, and channel that interest into related career paths.

Our plan is achieved through the demonstration of integrated applications of science, mathematics, and technology to the educational community.

HOME CONNECTION

Dear Parent or Guardian:

One of the activities that characterize the human race as a species is the desire to explore the world. At one time, oceans were a formidable barrier to exploring the planet; humans confined their curiosity to the land mass around them. Brave explorers ventured out onto the seas to search beyond the horizon when the level of curiosity and the promise of increased riches reached a critical point. Through exploration, travelers learned about new cultures and new animals and plants as well as the mineral riches of new lands.

We live in an era in which the new environment to be explored is space. Groups of pilots and scientists called astronauts routinely travel the Space Shuttle into orbit to study the effects of space travel on humans and the advantages of performing certain laboratory and commercial activities in microgravity.

The NASAEducation Program supports the development of family-centered education projects to stimulate parental involvement in their child's education and to become informed, active proponents for high-quality science, mathematics, and technology education in both school and non-school settings. The Home Connection exercise described below has been created by NASALangley's Office of Education and Learning Technologies Project Office to encourage parents and children to work together as a team in an online investigation in conjunction with the CONNECT microgravity program, Doing More In Less. We hope you have as much fun working together on this investigation as we had in developing it for you.

MATERIALS NEEDED

- Computer with internet access
- Fizzy-Tablet Rocket Worksheet (also available online)

PROCEDURE

Introduction: Access the CONNECT web page at http://edu.larc.nasa.gov/connect and click on the blinking Home Connection icon that is found on that page. Learn more about what the online team investigation is about and how to participate.

Experiment Set-Up: Follow the online instructions on selecting your rocket parts, fuel mixture and timing devices and on constructing your rocket for an online launch.

Launch Process: Launch your rocket and capture the animation of it from ignition to landing! Observe the flight time and record the time onto the online data table. Repeat the launch cycle three times for each fuel mixture selected and record the data.

Graphing and Analyzing Results: Next look at your collected data displayed in graph form and respond to the listed questions on the Fizzy-Tablet Rocket Worksheet (p. D4).

Multiple Tests: Repeat this Home Connection Online Team Investigation as often as you wish. You might want to keep track of your launch data results and compare results from multiple trials. See what patterns you might discover!

You are invited to participate in the CONNECT program, Microgavity: Doing More In Less. This live, interactive television program will be broadcast on local PBS stations. Check with your local PBS station for details on whether they will be carrying the program and whether the program will be carried live or rebroadcast at another time. The live program will occur on:

April 23	10:00-10:30 a.m., Grades 5-8
	1:30-2:00 p.m., Grades K-4

HOME CONNECTION
FIZZY-TABLET ROCKET WORKSHEET
ONLINE TEAM EXPERIMENT

Data Analysis

1. Which tablet took longer from ignition to landing? Why do you think that tablet took longer over the other tablet sizes?

____

2. Which tablet was the most consistent, that is, had about the same times?

____

3. What information can you deduce from the graph?

____

Think About It

1. How might the amount of water placed in the film canister affect how high the rocket will fly?

____

2. What difference in flight time might it make if the tablets were crushed before adding them to the canister?

____

3. How might the temperature of the water affect the flight time? Affect how high the rocket will fly?

____

Try It Out

Take two pieces of candy and crush one. Then give the whole candy piece to one person and the crushed candy to another person to dissolve in their mouths. Which candy will dissolve first? How might this experiment relate to our fizzy-tablet rocket?

Program 4 **Doing More In Less**

EVALUATION FORM

WHAT DID YOU THINK OF CONNECT: DOING MORE IN LESS?

Please take a few minutes to respond to the following questions.

School ___________________________________ School Division_____________________________________

School Zip Code _________________________ City, State ____

Grade Level / Subject ______________________ No. of students participating in program ____________

	Not at all		Somewhat		To a great extent
1. The program was valuable to					
a. your students	1	2	3	4	5
b. yourself as a teacher	1	2	3	4	5
2. The written materials were valuable to					
a. your students	1	2	3	4	5
b. yourself as a teacher	1	2	3	4	5
3. The Home CONNECT exercise was valuable to					
a. your students	1	2	3	4	5
b. yourself as a teacher	1	2	3	4	5
4. The program met your expectations	1	2	3	4	5
5. Did you view the program					
a. live	Yes		No		
b. videotape	Yes		No		

6. What comments or suggestions do you have for the program?

____

____

____

____

Thank you for your response.

Please fax evaluation form to: (757) 864-8835 or Mail to:

Attn: W.B. Williams, Ed.D.
NASA Langley Research Center
Office of Education
17 Langley Blvd. Mail Stop 400
Hampton VA 23681-0001